No. 4.— *Observations on the type specimen of the fossil cetacean Anoplonassa forcipata Cope.* By Frederick W. True.

I have recently had an opportunity of examining the type of the remarkable fossil cetacean *Anoplonassa forcipata* Cope, belonging to the Museum of Comparative Zoölogy. This specimen, on which the species was founded by Cope in 1869,[1] consists of the distal portion of a mandible, 191 mm. long. In the original description, Cope remarked that it was obtained, with remains of Mastodon, "not far from Savannah, Georgia." In 1890 he stated that it was from the "phosphatic deposits" of South Carolina.[2] His original description and figures are excellent, but the copies of the latter, published on a reduced scale in 1890, do not represent the specimen accurately. Faithful copies were published in Van Beneden and Gervais's Osteography of the Cetacea.[3]

Few cetologists have published any critical remarks on this interesting species and probably fewer still have ever seen the type and only known specimen. Cope, the original describer, was long in doubt as to its affinities, and, indeed, seems never to have come to a conclusion regarding them.

In 1869 he thought its relationships were with the "aberrant cetacea." "The nearest types," he remarked, "appear to be on the one hand Sirenia, and on the other, Squalodon."[4] In 1890 he actually placed it among the Sirenia, in the family Halitheriidae,[5] but cautiously remarked, "it is by no means certain that it belongs here, and it may be a Cetacean."

His remarks five years later (1895) indicate that he was then convinced that it was a cetacean and that it might be more or less closely related to the ziphioids. In describing his new genus Pelycorhamphus, which he assigns to the Choneziphiidae, he adds:

[1] Proc. Amer. Philos. Soc., **11**, p. 189, Plate 5.

[2] Amer. Nat., **24**, p. 700, Fig. 2. This apparent discrepancy may not be a real one, as Savannah is very close to the boundary line of South Carolina.

[3] Ostéographie des Cétacés, 1880, p. 386, text-fig.

[4] Proc. Amer. Philos. Soc., **11**, p. 189.

[5] Amer. Nat., **24**, Plate 700, Fig. 2.

"It would not be surprising if this genus should prove to be related to *Anoplonassa* Cope, which has the long symphysis mandibuli of the *Physeter*, with the nearly edentulous character of the Choneziphiidae." [1]

So far as I am aware, this is the final statement of Cope as regards Anoplonassa. The view that it was related to the ziphioid whales was not original with him, having been definitely published in Van Beneden and Gervais's Osteography, the title-page of which bears the date of 1880. On page 386 of that work, the authors remark: "We owe to Cope the description of a fossil fragment of a mandible of slender and elongated form, which comprises the greater part of the mandibular symphysis of a cetacean, without doubt related to (*voisin de*) *Hyperoödon* and *Ziphius*." [2]

It is to be noted that Leidy in 1869 assigned Anoplonassa to the Delphinidae, but with the statement that he accepted most of the fossil cetacean species on the authority of Cope, as he had neither time nor opportunity to examine the material on which they were based.[3] Leidy was probably influenced in this case by the view Cope held at the time, that Anoplonassa belonged to the "aberrant cetacea." Leidy's Delphinidae comprised all the Odontoceti, except Squalodon and its allies.

Brandt merely adopted the genus from Leidy, under the general heading of fossil delphinoids of North America.[4] Zittel merely cites the genus among the Ziphiinae,[5] being doubtless influenced by the opinion of Van Beneden and Gervais.

An examination of the type of Anoplonassa, and comparison of it with specimens of recent ziphioids in the National Museum, leave not the slightest doubt in my mind that it belongs to that group of cetaceans. It represents, however, a distinct section of the group. All recent ziphioids have the symphysis of the mandible comparatively short and the rami deep and compressed, while Anoplonassa has a very long symphysis, and it is highly probable that the rami were slender and rounded, somewhat as in Platanista. Although the ziphioids generally have a cranium with a long rostrum, externally the snout is quite short. In Anoplonassa, the snout was doubtless elongated, as in such forms as Platanista and Stenodelphis.

[1] Proc. Amer. Philos. Soc., **34**, p. 138.
[2] Ostéographie des Cétacés, 1880, p. 386.
[3] Journ. Acad. Nat. Sci. Phil., 1869, p. 436.
[4] Mem. Acad. St. Petersburg 1873 (7), **20**, p. 289.
[5] Handbuch der Paläontologie, 1893, **4**, Vertebrata, p. 179.

The chief features of the mandible of Anoplonassa are as follows: (1) Its slenderness; (2) the slight depth of the symphysis in proportion to its length, and the strong convexity of its sides; (3) the upturned and expanded termination; (4) the pair of large, nearly round, and very slightly depressed terminal alveoli; (5) the rudimentary alveolar groove, with its pair of rather small and shallow elliptical alveoli, not far distant from the terminal pair; (6) the large size and peculiar disposition of the inferior terminal foramina.

It is a well-known fact that in Mesoplodon and other existing genera of ziphioids, the superior alveolar border of the mandible in young individuals, at least, presents a shallow, more or less rudimentary, alveolar groove, and that in a certain proportion of specimens there are, in addition to the 2 or 4 large teeth, a number of very small, rudimentary teeth, which are imbedded in the integuments, and rest on, or partly in, the groove.

The groove itself occupies rather more than the anterior half of the superior border of the mandible. In Mesoplodon it is interrupted by the deep alveoli of the single pair of large teeth, which in most species are at a considerable distance from the anterior end of the mandible. In young specimens of Berardius, a genus with four large teeth, the interspace between the anterior tooth and the posterior tooth on each side is extremely small, and the rudimentary alveolar groove really begins behind the posterior tooth. In adults, however, the diastema between the anterior and posterior deep alveoli may be as much as 70 mm. This interspace is not depressed, but is rough and pierced by several canals.

In a mandible of *Ziphius cavirostris* 770 mm. long, the alveolar groove has a maximum width of about 9 mm. and a maximum depth of about 5 mm. In another imperfect mandible of Ziphius from an old individual the groove is deeper, especially anteriorly. The maximum depth is about 11 mm. In all the ziphioid mandibles examined, the groove is the broadest at the anterior and posterior ends. The floor of the groove is very uneven, and is pierced by numerous foramina for nutrient vessels and nerves. The edges of the groove in some specimens are quite smooth and straight. In others they are more or less crenulate, producing here and there the appearance of genuine alveoli, but these depressions never have the depth or the regular form of the alveoli of the large teeth.

The groove above described is found in Anoplonassa, with a similar general conformation and relative size. The walls, however, are more strongly crenulate than in specimens of existing ziphioids I have examined.

The opposite walls approach each other more frequently, and in a few places are bridged by transverse septa almost on the level of the superior surface. The groove has in consequence somewhat the appearance of a succession of shallow, elongated alveoli. Except at one point, however, it is improbable that any teeth were implanted in the jaw posterior to the large terminal pair, though some small rudimentary teeth may have been, and probably were, imbedded in the integuments above the groove, as in many specimens of recent ziphioids. At the point on the alveolar groove of Anoplonassa already referred to, at a distance of about 47 mm. posterior to the large terminal alveolus, is a second smaller and shallower one of an elliptical form. On the left side this has a length of about 13 mm., a width of about 7 mm., and a depth of about 3 mm. The floor has a granular appearance similar to that of the anterior alveolus. There can be no doubt that a pair of teeth was originally implanted in the jaw at this point, similar to, but much smaller than, the anterior pair, Anoplonassa in this respect resembling Berardius.

The large anterior pair of alveoli is situated immediately at the tip of the mandible. They occupy the whole width of the extremity of the jaw, which is considerably expanded to receive them. They are separated by a common median wall only about 4 mm. in breadth. Each alveolus is about 23 mm. long, 16 mm. broad, and has a maximum depth of about 5 mm. In the centre of each depression is a papilliform elevation. The whole floor of the alveolus is granular in appearance, as already mentioned, and consists of a fine bony network, surrounding small vascular openings. In these alveoli a pair of large teeth undoubtedly rested, as in Ziphius or Berardius. It is well known that in young ziphioids, and especially in the two genera just mentioned, the teeth are implanted in very deep alveoli, with only the tip projecting above the superior surface of the mandible. As the teeth grow they are pushed out more and more, so that finally their roots are scarcely at all below the superior surface of the jaw. In the meantime the vascular pulp below them ossifies and fills the alveolar cavity almost to the top, and on the upper surface of this bony network rests the root of the mature tooth.

This last stage is shown in the mandible of an adult Ziphius (Cat. No. 49599), from Newport, R.I., in the U. S. National Museum. Here the large anterior alveoli are filled to within about 12 mm. of the free margins with a spongy mass of bone, the upper surface of which is somewhat depressed.

The anterior alveoli of an adult *Berardius bairdii* from Bering Id. present a similar appearance on a larger scale. The resemblance of these

alveoli to those of Anoplonassa is very striking and is, I think, the result of a similar mode of dental growth.

The fragment from the anterior end of the symphysis of the mandible which constitutes the type of Anoplonassa, is nearly straight in its posterior two-thirds, but the tip is quite sharply curved upward, and, as already stated, considerably expanded. Just behind this expanded portion, the jaw is slightly constricted. These characters are, strictly speaking, peculiar to Anoplonassa as compared with recent ziphioids, but in adult or old specimens of Ziphius the superior surface of the symphysial region is curved upward, as in Berardius, although this surface is plane, the end of the jaw is rounded, and the terminal alveoli are directed upward rather than forward.

In cross-section, the type of Anoplonassa is shield-shaped, or rather, triangular, with one plane side (superior) and two convex sides. The chord of the convex sides of the jaw does not exceed the breadth of the superior surface, or in other words, a cross-section of the jaw has nearly the form of an equilateral triangle. On casual examination, it would appear that in Anoplonassa the symphysis is not as deep in proportion to its breadth as in existing ziphioids, but a comparison of measurements shows that in Mesoplodon and Berardius the breadth of the extremity of the jaw is about as great as its depth, and in adult Ziphius the breadth is considerably greater than the depth. It thus becomes obvious that it is not the breadth of the symphysis that makes the jaw of Anoplonassa seem so slender, but its great length. The appearance of the specimen indicates that only a portion of the symphysis has been preserved, and that the whole symphysis was much longer. Even in the fragment, however, the length is 6 times the depth, while in Ziphius and Mesoplodon the length of the complete symphysis is only from $2\frac{1}{3}$ to $5\frac{1}{2}$ times its greatest depth, and in Berardius but 2 times its depth.

It is difficult to conjecture how long the complete symphysis of Anoplonassa was originally, or what was the length of the entire mandible. That the symphysis was much longer than the fragment preserved is, as already stated, extremely probable, since the width at the posterior end of the fragment is only 7 mm. greater than the width immediately behind the posterior pair of alveoli. It is certain that the general conformation of the mandible must have been very different from that of any existing ziphioid, and that it resembled rather the mandible of a sperm whale (Physeter), or of one of the Plantanistidae, such as Platanista or Stenodelphis. If the upper jaw was equally

slender, the head must have resembled that of such long-beaked forms as Platanista, but if the maxillae were expanded, which is improbable, the head itself may have been broad and obtuse, as in Kogia or Physeter, and the lower jaw small and underhung. In either case, the appearance of the animal would be very different from that of any of the existing ziphioids, in which the snout is comparatively short and thick, or, in other words, of the shape commonly called "bottlenosed."

In Anoplonassa, the vessels and nerves which supply the mandible instead of issuing anteriorly through a number of foramina scattered irregularly along the rami in the vicinity of the symphysis, as is usual in some ziphioids and most Delphinidae, emerge close to the tip of the jaw in a nearly symmetrical fashion, there being two large foramina on each side immediately below the alveolus of the terminal tooth, with a smaller one between them. The foramina of each side are joined posteriorly by a quite deep groove, which runs along the inferior surface of the jaw nearly to the end of the fragment. The symphysis is strongly carinate in the median line, the internal edge of each half of the jaw being raised into a prominent ridge, which forms the inner boundary of the groove already mentioned. The keel extends from the tip of the mandible nearly to the end of the fragment, but fades out gradually posteriorly.

A very similar arrangement of foramina and ridges occurs in Ziphius and in Berardius. In the former genus the ridges forming the keel are shorter, and somewhat divergent. The canals extending backward from the anterior terminal foramina are much less strongly developed than in Anoplonassa and run into a large and sharply defined mental foramen, situated in line with the posterior end of the symphysis. The anterior foramina instead of remaining separate, are usually merged together, forming an opening of considerable size.

The conformation of Berardius is similar to that of Ziphius, except that usually the mental foramen assumes the form of a long trough situated a little in front of the posterior end of the symphysis and followed posteriorly by one or more additional foramina. It is probable that at the posterior end of the symphysis of Anoplonassa there was a similar foramen or trough. That it is not found on the type specimen is an additional indication that the posterior end of the symphysis is lacking.

While the form of the alveoli, alveolar groove, and mandibular foramina of Anoplonassa denote clearly that it belongs to the subfamily Ziphiinae, it obviously represents a section of that subfamily distinct

from the section to which the recent genera belong. Leaving out of consideration other fossil forms presently to be mentioned, one might properly separate the Ziphiinae from the Physeteridae and, following J. E. Gray, give them the full rank of a family. The family would be divided into three sections, consisting respectively, (1) of Hyperoödon, (2) the other recent genera, and (3) Anoplonassa.

Very recently Dr. O. Abel has called attention to three fossil forms [1] two of which at least are somewhat closely allied to Anoplonassa. These are *Palaeoziphius scaldensis* (Du Bus), *Cetorhynchus atavus* Abel and *Mioziphius belgicus* Abel, all from the Upper Miocene of Antwerp. Of these, *P. scaldensis* is considered by Abel to be the oldest. The size of the mandible is about the same as in Anoplonassa. The length of the entire symphysis in proportion to its depth is about the same as the length of the fragment of the symphysis of Anoplonassa to its depth. Palaeoziphius, however, has 14 alveoli on each side, between most of which are well-formed septa whose upper surface is in the same plane with the upper surface of the jaw. Dr. Abel states that the anterior end of the jaw is slightly expanded, but the figure which accompanies his description does not indicate such an expansion, and we may suppose that it is at best only slight. It is also stated that the symphysial region is semicircular in transverse section and that the end of the jaw is turned upward.

In Cetorhynchus, which is larger than Anoplonassa, the alveolar groove is rudimentary and the septa are imperfect and do not reach the level of the upper surface of the jaw. This upper surface is concave, while on the sides of the mandible there is a deep mental groove. The transverse section of the jaw is semicircular.

In *Mioziphius belgicus* the mandible is much more slender than in Cetorhynchus, but, judged by the symphysial region, is about a half larger than Anoplonassa. Instead of a series of well-formed, or imperfect, alveoli, it has a narrow and shallow rudimentary alveolar groove and two pairs of very large alveoli resembling those of Anoplonassa very closely in some particulars, though the second pair is larger in proportion to the terminal one than in that genus. The terminal alveoli are filled with a mass of cancellous tissue which has a concave surface and a central eminence, as in Anoplonassa, and the alveoli themselves are separated by a narrow median partition. The jaw is expanded at the end where these alveoli are situated. The mass in the posterior alveoli, beside filling the cavity of the latter, appears to protrude considerably

[1] Mém. Mus. Roy. Hist. Nat. Belg., 1905, 3.

beyond the upper surface of the jaw, and in this respect as well as in the larger size of the alveoli themselves, the specimen departs widely from Anoplonassa. I cannot discover that Dr. Abel has given any information regarding the depth of the mandible, but he states that the symphysis is short. In the figure which accompanies the description the jaw is $\frac{1}{4}$ wider at the line of the posterior end of the symphysis than immediately behind the anterior alveoli.

As regards the relations of *Palaeoziphius scaldensis* to *Anoplonassa*, Dr. Abel remarks: —

"The genus *Anoplonassa*, from the Phosphate Beds of Savannah (Georgia), represents a phase of development in which the alveolar canals of the mandible have become rudimentary, with two pairs of teeth [*i. e.*, alveoli] close together; the anterior terminal pair is twice as large as the second pair, which is situated at about the middle of the length of the symphysis. The jaw recalls that of *Squalodon* in general form.

"Although one may without hesitation unite *Anoplonassa* with the ziphioids, until now those stages (of development) have been lacking which lead from *Anoplonassa* to the oldest polyodont and homodont ancestors of the ziphioids. This intermediate form is now represented by the type that Du Bus has described under the name of *Chamsodelphis Scaldensis* [= *Palaeoziphius scaldensis* (Abel)].

"In a comparison with *Anoplonassa* the agreement in size, the length of the symphysis, and the upward inflection of the anterior extremity [of the mandible] immediately strike the eye; the jaw from the Antwerp Boldérien also recalls that of *Squalodon*. But that which at once clearly distinguishes the Antwerp jaw from that of the Phosphate Beds of Savannah, Georgia, is the presence of 14 alveoli in each half of the symphysis." [1]

The foregoing quotation appears to indicate that Dr. Abel considers Palaeoziphius the nearest known ally of Anoplonassa, and hence more closely related to it than are Cetorhynchus or Mioziphius. The reasons which induce him to assign Palaeoziphius to the Ziphiidae are not stated in his paper, so far as I can discover, except as appears in the comparison with Anoplonassa above quoted. The resemblances between the two genera therein mentioned are: (1) the approximately equal size, (2) the expansion of the end of the mandible, (3) its upturned extremity.

As already alluded to, the size of the mandible is somewhat larger in Anoplonassa. The symphysis is certainly somewhat longer, and probably much longer. The expansion of the end of the mandible is much greater; indeed, in Palaeoziphius it is so slight as not to be appreciable in the figure given by Dr. Abel. It is true that Anoplonassa has the

[1] *Loc. cit.*, (1905), p. 92.

end of the jaw upturned, but this is quite probably an age character, as in the recent genus Ziphius old individuals have the extremity of the jaw strongly recurved, while in young individuals the angle between the axis of the symphysis and the axis of the rami is very obtuse.

It appears to me that the evidence that Palaeoziphius belongs to the ziphioids is not convincing, though it is conceivable that the ancestors of the recent genera may have been some such form with a series of functional teeth. It has to be remembered that Palaeoziphius, Cetorhynchus, and Mioziphius are all from the upper Miocene, and that Anoplonassa was also probably derived from the Miocene.

In my opinion Mioziphius is a much nearer relative of Anoplonassa than is Palaeoziphius. That it is of larger size and has a shorter symphysis does not seem to me to exclude the idea of close relationship. It is a well-known fact that closely allied recent genera of cetaceans, such as Steno and Sotalia, or Steno and Tursiops, among the Delphinidae, differ greatly in the two characters mentioned. In the genus Mesoplodon the length of the symphysis varies very considerably in different species. In the general conformation of the symphysis, in the general form, details of structure, and relative positions of the alveoli, and in the form of the end of the jaw, Mioziphius certainly exhibits a striking resemblance to Anoplonassa. These characters, I think, greatly outweigh those of size and of length of symphysis, and make it proper to unite the two genera in a separate section of the Ziphiidae.

Certain crania, as well as mandibles, are assigned to *Mioziphius belgicus* by Dr. Abel, though he does not give the evidence on which the reference of the former to that genus and species is based. Presuming that these crania and jaws really do belong to the same species, it will be interesting to consider Cope's view, expressed in 1895, that the cranium known as Pelycorhamphus may belong to the same genus as the jaw known as Anoplonassa.[1]

Cope's description of the cranium of Pelycorhamphus indicates a form sharing some of the characters of Choneziphius, with others of Paracetus, Kogia, etc., and having as a peculiar feature the expansion of the proximal end of the vomer, forming a wide basin which overlaps the maxillary. There appears to be some trace of this latter character in *Mesoplodon layardi*, but nothing resembling it occurs in Mioziphius. It seems, therefore, that if Dr. Abel has correctly associated the mandible No. 3854 of the Brussels Museum with the cranium of Mioziphius, Pelycorhamphus has nothing to do with Anoplonassa. I am by no means

[1] Proc. Amer. Philos. Soc., 1895, **34**, p. 138.

convinced, however, that such is the case, but believe that Cope's surmise may prove correct. Until more material is collected, the question at issue cannot, I think, be satisfactorily settled.

The dimensions of the type specimen of *Anoplonassa forcipata* are as follows: —

Total length	191 mm.
Greatest breadth at the posterior end	34
" " at the anterior end (across the centre of the anterior pair of alveoli)	34
Least breadth behind the anterior pair of alveoli	27
Breadth across centre of posterior " " "	32
Vertical depth at posterior end of fragment	29
" " opposite the posterior pair of alveoli	26
" " " the hind margin of the anterior pair of alveoli	30
Greatest breadth between inner margins of rudimentary alveolar canal posteriorly	24
Breadth between the same, midway from anterior to posterior pairs of alveoli	16
Least breadth between posterior alveoli	14
" " " anterior alveoli	4
Length of posterior alveolus (left)	13
Breadth " " "	7
Length of anterior alveolus (left)	23
Breadth " " "	16